

**Series ONS**

**SET-1**

Roll No.

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Candidates must write code on the title page of the answer –book

- Please check that this question paper contains 16 printed pages.
- Code number given on the right hand side of the question paper should be written on the title page of the answer-book by the candidate.
- Please check that this question paper contains 26 questions.
- Please write down the Serial Number of the question before attempting it.
- 15 minute time has been allotted to read this question paper. The question paper will be distributed at 10.15 a.m. From 10.15 a.m. to 10.30 a.m., the students will read the question paper only and will not write any answer on the answer-book during this period.

## **PHYSICS (Theory)**

**Time allowed : 3 hours**

**Maximum Marks : 70**

General Instructions :

- All questions are **compulsory**. There are **26** questions in all.*
- This question paper has **five** sections : Section A, Section B, Section C, Section D and Section E.*

- (iii) Section A contains **five** questions of one mark each, Section B contains five questions of two marks each, Section C contains **twelve** questions of **three** marks each, Section D contains **one** value based question of **four** marks and Section E contains **three** questions of **five** each.
- (iv) There is no overall choice. However, an internal choice has been provided in **one** question of **two** marks, **one** question of **three** marks and all the **three** questions of **five** marks weightage. You have to attempt only **one** of the choice in such questions.
- (v) You may use the following values of physical constants wherever necessary.

$$c = 3 \times 10^8 \text{ m/s}$$

$$h = 6.63 \times 10^{-34} \text{ Js}$$

$$e = 1.6 \times 10^{-19} \text{ C}$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ T m A}^{-1}$$

$$\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$$

$$\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \text{ Nm}^2 \text{ C}^{-2}$$

$$\text{Mass of electron} = 9.1 \times 10^{-31} \text{ kg}$$

$$\text{Mass of neutron} = 1.675 \times 10^{-27} \text{ kg}$$

$$\text{Mass of proton} = 1.673 \times 10^{-27} \text{ kg}$$

$$\text{Avogadro's number} = 6.023 \times 10^{23} \text{ per gram mole}$$

$$\text{Boltzmann constant} = 1.38 \times 10^{-23} \text{ JK}^{-1}$$

**SECTION - A**

1. What is the amount of work done in moving a point charge  $Q$  around a circular arc of radius ' $r$ ' at the centre of which another point charge ' $q$ ' is located ? [ 1 ]
2. Define mobility of a charge carrier. What is its relation with relaxation time ? [ 1 ]
3. What can be the cause of helical motion of a charged particle ? [ 1 ]
4. Why can't we see clearly through fog ? Name the phenomenon responsible for it. [ 1 ]
5. A signal of 5 kHz frequency is amplitude modulated on a carrier wave of frequency 2 MHz. What are the frequencies of the side bands produced ? [ 1 ]

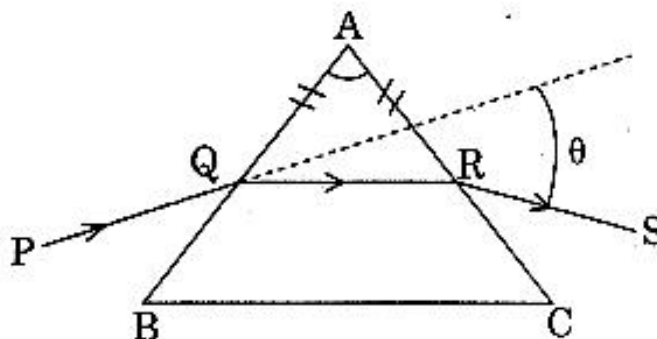
**SECTION - B**

6. When 5V potential difference is applied across a wire of length 0.1 m, the drift speed of electrons is  $2.5 \times 10^{-4}$  m/s. If the electron density in the wire is  $8 \times 10^{28}$  m<sup>-3</sup>, calculate the resistivity of the material of wire. [ 2 ]
7. A proton and an  $\alpha$  particle are accelerated through the same potential difference. Which one of the two has (i) greater de-Broglie wavelength, and (ii) less kinetic energy ? Justify answer. [ 2 ]
8. When is  $H_{\alpha}$  line in the emission spectrum of hydrogen atom obtained ? Calculate the frequency of the photon emitted during this transition. [ 2 ]

OR

Calculate the wavelength of radiation emitted when electron in a hydrogen atom jumps from  $n = \infty$  to  $n = 1$

9. Why is base band signal not transmitted directly ? Give any two reasons. [ 2 ]
10. A ray PQ incident on the refracting face BA is refracted in the prism BAC as shown in the figure and emerges from the other refracting face AC as RS such that  $AQ = AR$ . If the angle of prism  $A = 60^\circ$  and refractive index of material of prism is  $\sqrt{3}$ , calculate angle  $\theta$ .



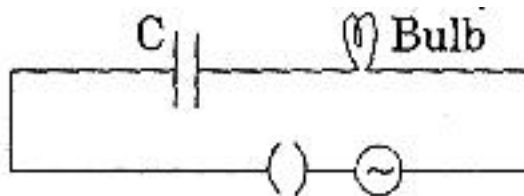
**SECTION - C**

11. Find the electric field intensity due to a uniformly charged spherical shell at a point (i) outside the shell and (ii) inside the shell. Plot the graph of electric field with distance from the centre of the shell. [3]
12. Two identical cells of emf 1.5 V each joined in parallel supply energy to an external circuit consisting of two resistances of 7  $\Omega$  each joined in parallel. A very high resistance voltmeter reads the terminal voltage of cells to be 1.4 V. Calculate the internal resistance of each cell. [3]
13. State Ampere's circuital law. Use this law to find magnetic field due to straight infinite current carrying wire. How are the magnetic field lines different from the electrostatic field lines ? [3]

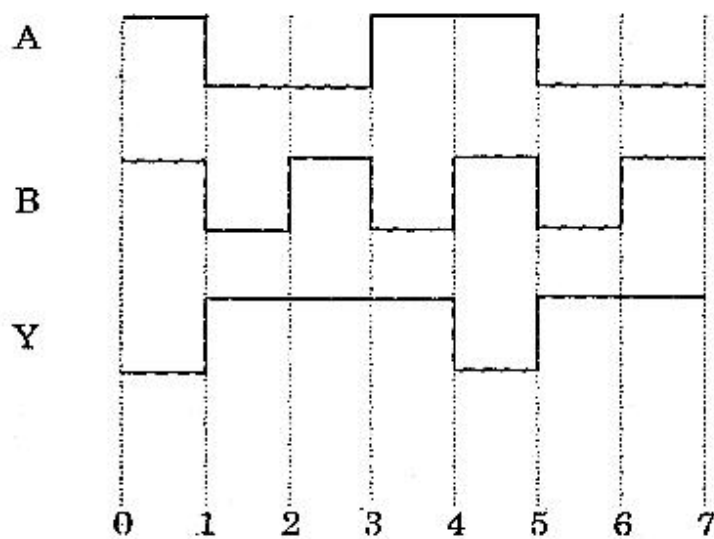
"OR"

State the principle of a cyclotron. Show that the time period of revolution of particles in a cyclotron is independent of their speeds. Why is this property necessary for the operation of a cyclotron ?

14. (i) When an AC source is connected to an ideal capacitor, show that the average power supplied by the source over a complete cycle is zero.  
(ii) A bulb is connected in series with a variable capacitor and an A.C. source as shown. What happens to the brightness of the bulb when the key is plugged in and capacitance of the capacitor is gradually reduced? [3]



15. How are electromagnetic waves produced ? What is the source of energy of these waves ? Write mathematical expressions for electric and magnetic fields of an electromagnetic wave propagating along the z-axis. Write any two important properties of electromagnetic waves. [3]
16. (i) Derive Snell's law on the basis of Huygen's wave theory when light is travelling from a denser to a rarer medium.  
(ii) Draw the sketches to differentiate between plane wavefront and spherical wavefront. [3]
17. State two important properties of photon which are used to write Einstein's photoelectric equation. Define (i) stopping potential and (ii) threshold frequency, using Einstein's equation and drawing necessary plot between relevant quantities. [3]
18. (i) Name two important processes that occur during the formation of a pn junction.  
(ii) Draw the circuit diagram of a full wave rectifier along with the input and output waveforms. Briefly explain how the output voltage/current is unidirectional. [3]
19. (i) Distinguish between a conductor and a semi conductor on the basis of energy band diagram.  
(ii) The following figure shows the input waveforms (A, B) and the output waveform (Y) of a gate. Identify the gate, write its truth table and draw its logic symbol. [3]



20. What is space wave propagation ? State the factors which limit its range of propagation. Derive an expression for the maximum line of sight distance between two antennas for space wave propagation. [ 3 ]
21. (i) Derive the mathematical expression for law of radioactive decay for a sample of a radioactive nucleus.  
(ii) How is the mean life of a given radioactive nucleus related to the decay constant ? [ 3 ]
22. (i) A screen is placed at a distance of 100 cm from an object. The image of the object is formed on the screen by a convex lens for two different locations of the lens separated by 20 cm. Calculate the focal length of the lens used.  
(ii) A converging lens is kept coaxially in contact with a diverging lens - both the lenses being of equal focal length. What is the focal length of the combination ? [ 3 ]

### SECTION - D

23. Seema's uncle was advised by his doctor to have an MRI (Magnetic Resonance Imaging) scan of his brain. Her uncle felt it to be expensive and wanted to postpone it. When Seema learnt about this, she took the help of her family and also approached the doctor, who also offered a substantial discount. She then convinced her uncle to undergo the test to enable the doctor to know the condition of his brain. The information thus obtained greatly helped the doctor to treat him properly.

Based on the above paragraph, answer the following questions :

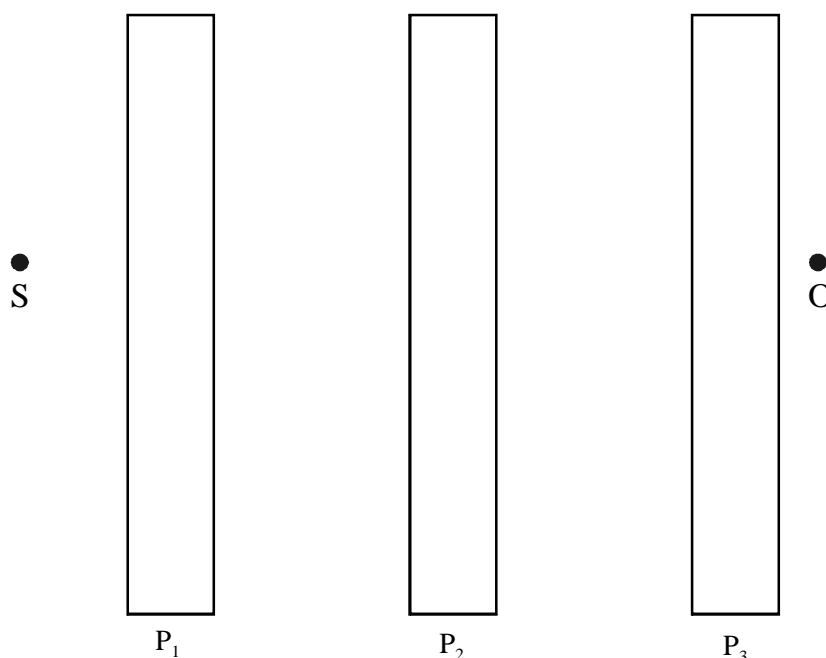
- (a) What according to you are the values displayed by Seema, her family and the doctor ?
- (b) What could be the possible reason for MRI test to be so expensive ?
- (c) Assuming that MRI test was performed using a magnetic field of 0.1 T., find the minimum and maximum values of the force that the magnetic field could exert on a proton (charge =  $1.6 \times 10^{-19}$  C) moving with a speed of 104 m/s. [ 4 ]



OR

In a series LCR circuit connected to an a.c. source of voltage  $v = v_m \sin \omega t$ , use phasor diagram to derive an expression for the current in the circuit. Hence obtain the expression for the power dissipated in the circuit, Show that power dissipated at resonance is maximum.

26. (a) Why does unpolarised light from a source show a variation in intensity when viewed through a polaroid which is rotated? Show with the help of a diagram, how unpolarised light from sun gets linearly polarised by scattering.
- (b) Three identical polaroid sheets  $P_1$ ,  $P_2$  and  $P_3$  are oriented so that the pass axis of  $P_2$  and  $P_3$  are inclined at angles of  $60^\circ$  and  $90^\circ$  respectively with the pass axis of  $P_1$ . A monochromatic source  $S$  of unpolarized light of intensity  $I_0$  is kept in front of the polaroid sheet  $P_1$  as shown in the figure. Determine the intensities of light as observed by the observed at  $O$ , when polaroid  $P_3$  is rotated with respect to  $P_2$  at angles  $\theta = 30^\circ$  and  $60^\circ$ .



OR

- (a) Derive an expression for path difference in Young's double slit experimer and obtain the condition for constructive and destructive interference at a point on the screen.
- (b) The intensity at the central maxima in Young's double slit experiment is  $I_0$ . Find out the intensity at a point where the path difference is  $\frac{\lambda}{6}$ ,  $\frac{\lambda}{4}$  and  $\frac{\lambda}{3}$ .